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(71)Applicant : SUMITOMO METAL IND LTD

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(72)Inventor : KAMATA KYOKO  
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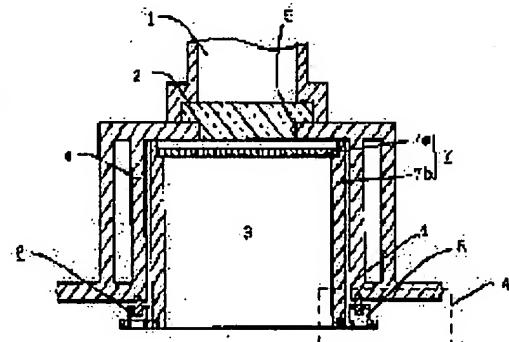
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## (54) MICROWAVE PLASMA DEVICE

### (57)Abstract:

PURPOSE: To prevent the deformation or breakage due to thermal expansion of an adhesion preventing cylinder in a microwave plasma device having a prescribed configuration and improve the reproducibility of plasma treatment by holding the adhesion preventing cylinder by a specified means.

CONSTITUTION: This microwave plasma device has a plasma generating chamber 3, a microwave guide window 2 for guiding a microwave into the plasma generating chamber 3, and an adhesion preventing cylinder 7 for covering the inner wall of the plasma generating chamber 3 provided on the inner part of the plasma generating chamber 3. In this device, the lower end of the adhesion preventing cylinder 7 is held by an elastic adhesion preventing cylinder holding means 8 to make the clearance between the adhesion preventing cylinder 7 and the microwave guide window 3 constant. Consequently, the removal and replacement of the adhesion preventing cylinder 7 are also facilitated.



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**CLAIMS**

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**[Claim(s)]**

[Claim 1] Microwave plasma equipment characterized by being microwave plasma equipment which equips with a wrap adhesion-proof cylinder a plasma production room, the microwave installation aperture which introduces microwave into said plasma production room, and the interior of said plasma production room for the wall of a plasma production room, and being held by adhesion-proof cylinder maintenance means by which the above-mentioned adhesion-proof cylinder has elasticity in the soffit, and the gap of the above-mentioned adhesion-proof cylinder and a microwave installation aperture being fixed.

[Claim 2] The microwave plasma equipment characterized by to be microwave plasma equipment equipped with a wrap adhesion-proof cylinder, to be located the space more than the amount of thermal expansion of the above-mentioned adhesion-proof cylinder between the soffit of the above-mentioned adhesion-proof cylinder, and a sample base in the wall of a plasma-production room in a plasma-production room, the microwave installation aperture which introduces microwave into said plasma-production room, and the interior of said plasma-production room, and to be held the above-mentioned adhesion-proof cylinder by the adhesion-proof cylinder maintenance means near [ the ] the upper bed at the plasma-production room.

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**DETAILED DESCRIPTION**

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**[Detailed Description of the Invention]**

**[0001]**

**[Industrial Application]** This invention relates to the microwave plasma equipment used for etching of a semiconductor device substrate, thin film formation, etc.

**[0002]**

**[Description of the Prior Art]** In manufacture of a semiconductor device, by introducing microwave in the vacuum housing under reduced pressure, the plasma is made to generate and the microwave plasma equipment which irradiates this plasma on the surface of a sample, and processes etching, thin film formation, etc. is used.

**[0003]** Drawing 9 is typical drawing of longitudinal section showing the microwave plasma equipment using the electron cyclotron resonance excitation which is one sort of microwave plasma equipment. Three in drawing is a plasma production room, opening of the microwave inlet 5 is carried out in the center of the upper part of this plasma production room 3, and the vacuum lock of it is carried out by the microwave installation apertures 2, such as a quartz. The waveguide 1 by which that other end side was connected to the microwave oscillator which is not illustrated is attached in this microwave inlet 5. The plasma production interior wall 4 is double structure, and is equipped with the conduction room 6 for carrying out conduction of the cooling water.

**[0004]** The sample rooms 10 are formed successively by the plasma production room 3 bottom, the sample base 14 is arranged in this sample room 10, and the samples S, such as a wafer, are laid removable with means, such as electrostatic adsorption, on this sample base 14. Moreover, the exhaust port 13 which the gas installation tubing 12 is connected with the sample interior wall 11, and is connected with an exhauster (not shown) is established.

**[0005]** The exiting coil 9 is attached around the outside of the plasma production room 3. And the up wall and the side attachment wall are attached in the wrap adhesion-proof cylinder 7 by the lower wall of a plasma production room with the adhesion-proof cylinder maintenance means 8 so that each wall of the plasma production room 3 may not receive the direct exposure of the generated plasma in the interior of the plasma production room 3. It mentions later about this point.

**[0006]** Drawing 10 is the enlarged drawing of plasma production room 3 parts. The adhesion-proof cylinder 7 counters with the microwave installation aperture 2, and consists the side-attachment-wall section of wrap top-face section 7a and the plasma production room 3 of wrap cylinder part 7b in the up wall of the plasma production room 3, and cylinder part 7b is usually formed of a quartz, an alumina, aluminum, etc. with a quartz, an alumina, etc. whose top-face section 7a is the transparency ingredient of microwave. Top-face section 7a and cylinder part 7b may be formed in one. The adhesion-proof cylinder 7 is in the condition laid on adhesion-proof cylinder retaining ring 8a, and fixed maintenance is carried out by bolt 8c at the plasma production interior wall 4 through hole 8b which was able to be opened in adhesion-proof cylinder retaining ring 8a.

**[0007]** How to etch using the microwave plasma equipment of the above configurations is explained (refer to drawing 9 ).

[0008] After exhausting the inside of the plasma production room 3 to a predetermined pressure first, from the gas installation tubing 12, the gas for etching is introduced and it considers as a predetermined pressure. And microwave is introduced into the plasma production room 3 through the microwave installation aperture 2, forming a field with an exiting coil 9. Then, the plasma generates by electron cyclotron resonance excitation in the plasma production interior of a room. It is projected by the sample S in the sample room 10, and Sample S is etched by the divergence field to which a field falls as the generated plasma is formed with an exiting coil 9 and it goes to the sample room 10.

[0009] However, in the microwave plasma equipment of the above-mentioned configuration, when microwave was introduced and long duration generation of the plasma was carried out, the adhesion-proof cylinder 7 was heated by the plasma, the dimensional change happened by thermal expansion, the gap of top-face section 7a of an adhesion-proof cylinder and the microwave installation aperture 2 changed, the generation condition of the plasma changed by this, and there was a problem of worsening the repeatability of plasma treatment.

[0010] On the other hand, these people have proposed the equipment which holds the gap of top-face section 7a of an adhesion-proof cylinder, and the microwave installation aperture 2 to a predetermined value by forming the gap attachment component 21 between top-face section 7a of an adhesion-proof cylinder, and the up wall of the plasma production room 3, as shown in drawing 11 (refer to JP,6-252100,A).

[0011]

[Problem(s) to be Solved by the Invention] However, it sets to the equipment given in JP,6-252100,A which equips the gap of top-face section 7a of the above-mentioned adhesion-proof cylinder, and the up wall of the plasma production room 3 with the gap attachment component 21. Since the soffit of cylinder part 7b of an adhesion-proof cylinder was laid for maintenance of the adhesion-proof cylinder 7 on adhesion-proof cylinder retaining ring 8a and adhesion-proof cylinder retaining ring 8a was performed by fixing to the lower wall of the plasma production interior wall 4 by bolt 8c, When the plasma was generated for a long time, the adhesion-proof cylinder 7 expanded thermally by plasma heating, and it deformed, when excessive, it was divided, and in connection with the thermal expansion of the adhesion-proof cylinder 7, adhesion-proof cylinder retaining ring 8a deformed, and when it was exchange of the adhesion-proof cylinder 7, there was a problem that removal became difficult.

[0012] This invention aims at offering the microwave plasma equipment difficult for removal of deformation by the thermal expansion of an adhesion-proof cylinder, crack breakage, or an adhesion-proof cylinder which is not while it makes repeatability of plasma treatment good.

[0013]

[Means for Solving the Problem] The microwave installation aperture to which this invention introduces microwave into a plasma production room and said plasma production room, It is microwave plasma equipment which equips the interior of said plasma production room with a wrap adhesion-proof cylinder for the wall of a plasma production room. The above-mentioned adhesion-proof cylinder is held by the adhesion-proof cylinder maintenance means which has elasticity in the soffit. It is characterized by the gap of the above-mentioned adhesion-proof cylinder and a microwave installation aperture being fixed, and the space more than the amount of thermal expansion of the above-mentioned adhesion-proof cylinder is between the soffit of the above-mentioned adhesion-proof cylinder, and a sample base, and it is characterized by holding the above-mentioned adhesion-proof cylinder by the adhesion-proof cylinder maintenance means near [ the ] the upper bed at the plasma production room.

[0014]

[Function] This invention equipment can absorb the thermal expansion of the adhesion-proof cylinder at the time of plasma production by telescopic motion of a resilient part, fixing the upper bed of an adhesion-proof cylinder, since the adhesion-proof cylinder was held by the adhesion-proof cylinder maintenance means which has elasticity in the soffit. While being able to hold the gap of an adhesion-proof cylinder and a microwave installation aperture to a fixed value and making repeatability of plasma production good by this, it can prevent that originate in deformation of an adhesion-proof cylinder, or crack breakage or deformation of an adhesion-proof cylinder retaining ring, and removal of an adhesion-

proof cylinder becomes difficult.

[0015] Moreover, since the adhesion-proof cylinder is held by the adhesion-proof cylinder maintenance means near [ the ] the upper bed at the plasma production room, the elongation by the thermal expansion of an adhesion-proof cylinder appears in the soffit of an adhesion-proof cylinder, and there is almost no effect of elongation to the gap of an adhesion-proof cylinder and a microwave installation aperture. Moreover, the soffit of an adhesion-proof cylinder also has neither deformation of an adhesion-proof cylinder nor fear of crack breakage, even if the soffit of an adhesion-proof cylinder is extended by thermal expansion, since it is not fixed but the sufficient room more than the amount of thermal expansion of an adhesion-proof cylinder is between the soffit of an adhesion-proof cylinder, and a sample base again. Moreover, since the adhesion-proof cylinder retaining ring is not used, it originates in this deformation and removal of an adhesion-proof cylinder does not become difficult.

[0016]

[Example] Hereafter, the example of the microwave plasma equipment of this invention is explained based on a drawing.

[0017] Drawing 1 is the typical sectional view of plasma production room 3 parts of the microwave plasma equipment of the 1st example. The adhesion-proof cylinder 7 consists of cylinder part 7b made from aluminum, and top-face section 7a made from an alumina, and the upper bed section of cylinder part 7b is formed so that it may have the level difference in which a periphery projects, and it has the composition of holding top-face section 7a on this level difference. The adhesion-proof cylinder 7 is being fixed to the lower wall of the plasma production interior wall 4 by the adhesion-proof cylinder maintenance means 8 in the soffit of cylinder part 7b so that the upper bed of cylinder part 7b may touch the up wall of the plasma production room 3.

[0018] The approach of maintenance of the adhesion-proof cylinder maintenance means 8 and an adhesion-proof cylinder is explained in full detail. Drawing 2 is the enlarged drawing of the adhesion-proof cylinder attaching part part A in drawing 1 , drawing 4 is the typical sectional view which looked at the B-B' cross section from the direction of an arrow head, and drawing 3 is the mimetic diagram of the adhesion-proof cylinder maintenance means 8 before being attached in the lower wall of the plasma production interior wall 4 by bolt 8c.

[0019] As shown in drawing 3 , the adhesion-proof cylinder maintenance means 8 mainly consists of adhesion-proof cylinder retaining ring 8a made from aluminum by which 8d of four flat springs which have bolthole 8e has been arranged. 8d of this flat spring is being fixed to adhesion-proof cylinder retaining ring 8a by bolt 8f in ends, respectively. In case hole 8b attaches adhesion-proof cylinder retaining ring 8a in the lower wall of the plasma production interior wall 4 by bolt 8c, it is for attaching bolt 8c from the adhesion-proof cylinder retaining ring 8a bottom.

[0020] As shown in drawing 2 , cylinder part 7b of an adhesion-proof cylinder is laid in the inner circumference section of adhesion-proof cylinder retaining ring 8a, and adhesion-proof cylinder retaining ring 8a is being fixed to the lower wall of the plasma production interior wall 4 through bolthole 8e opened in 8d of flat springs by bolt 8c. This immobilization is performed so that the upper bed of cylinder part 7b of an adhesion-proof cylinder may touch the up wall of the plasma production room 3.

[0021] As shown in drawing 4 , adhesion-proof cylinder retaining ring 8a in which the adhesion-proof cylinder is laid is in the condition of having been held so that it might lift through 8d of flat springs by bolt 8c fixed to the lower wall of the plasma production interior wall 4. Therefore, although the force joins adhesion-proof cylinder retaining ring 8a downward when cylinder part 7b of an adhesion-proof cylinder expanded and develops, it is absorbable with the deflection of 8d of flat springs.

[0022] That is, since the adhesion-proof cylinder 7 is held by the adhesion-proof cylinder maintenance means 8 so that the upper bed of cylinder part 7b may touch the up wall of the plasma production room 3 even when long duration generation of the plasma is carried out by the above configuration, by the die length specified by the wire extension of this cylinder part 7b, the gap of top face section 7a of an adhesion-proof cylinder and the microwave installation aperture 2 is held uniformly, and does not change. Moreover, since adhesion-proof cylinder retaining ring 8a moves downward by the deflection of

8d of flat springs when the soffit of cylinder part 7b is extended downward by expansion by the plasma heating of cylinder part 7b of an adhesion-proof cylinder, the big force to an adhesion-proof cylinder and an adhesion-proof cylinder retaining ring will not be added, but, as a result, deformation of an adhesion-proof cylinder and deformation of an adhesion-proof cylinder retaining ring will be prevented. [0023] That there are not deformation of the repeatability of plasma treatment and an adhesion-proof cylinder and deformation of an adhesion-proof cylinder retaining ring by the equipment of this example has checked by the plasma production of the long duration by Ar gas plasma.

[0024] Moreover, a coiled form spring may be used instead of a flat spring as what supplies the force pushed up elastically. Drawing 5 is this example, and the both ends of that spring are fixed between adhesion-proof cylinder retaining ring 8a and 8h of support plates, coiled form spring 8g is prepared in it, and it is fixed to the lower wall of the plasma production interior wall 4 by bolt 8c through bolthole 8i which was able to be opened in 8h of support plates. In this case, adhesion-proof cylinder retaining ring 8a will be in the condition of having been held through 8h of support plates, and coiled form spring 8g so that it might lift. Although the force joins adhesion-proof cylinder retaining ring 8a downward like a previous example when the cylinder part of an adhesion-proof cylinder expanded and develops, it is absorbable with expanding of coiled form spring 8g.

[0025] Drawing 6 is the typical sectional view of plasma production room 3 parts of the microwave plasma equipment of the 2nd example. The adhesion-proof cylinder 7 consists of cylinder part 7b made from a quartz, and top-face section 7a made from a quartz, and the upper bed section of cylinder part 7b is formed so that it may have the level difference in which a periphery projects, and it has the composition of holding top-face section 7a on this level difference. In this example, instead of holding in the soffit of cylinder part 7b of an adhesion-proof cylinder, it fixed to the plasma production interior wall 4 near the upper bed, and considered as the configuration which hangs and holds the adhesion-proof cylinder 7. In order to hang, while preparing four overhang partial 4c for maintenance in the plasma production interior wall 4 toward the inside, as shown also in drawing 7 corresponding to it, four overhang partial 7c for maintenance was prepared also in the upper bed part of cylinder part 7b of an adhesion-proof cylinder toward the outside. As it attaches and is shown in drawing 8 as a direction, the adhesion-proof cylinder 7 is pushed up from the bottom, it inserts into the plasma production room 3, this is rotated, and overhang partial 7c of an adhesion-proof cylinder carries and attaches in overhang partial 4c of the plasma production interior wall 4. At this example, what bars the thermal expansion of cylinder part 7b of the adhesion-proof cylinder 7 from the soffit of the adhesion-proof cylinder 7 up to the sample base 14 does not have anything.

[0026] Since the fixed point with the plasma production room of the adhesion-proof cylinder 7 is near the upper bed of cylinder part 7b and the elongation of cylinder part 7b of the adhesion-proof cylinder by plasma heating mainly appears as elongation of the soffit of cylinder part 7b of an adhesion-proof cylinder even when long duration generation of the plasma is carried out by the above configuration, there is almost no effect of the elongation of cylinder part 7b of an adhesion-proof cylinder to the gap of top-face section 7a of an adhesion-proof cylinder and the microwave installation aperture 2. Moreover, it is the structure where the adhesion-proof cylinder 7 was hung, and up to the sample base 14 from the soffit of the adhesion-proof cylinder 7, since there is nothing, even if the soffit of cylinder part 7b of an adhesion-proof cylinder develops by thermal expansion, neither deformation of the adhesion-proof cylinder 7 nor fear of crack breakage is.

[0027] Also in the equipment of this example, it has checked by the plasma production of the long duration by Ar gas plasma that there are no deformation and crack breakage of the repeatability of plasma treatment and an adhesion-proof cylinder.

[0028]

[Effect of the Invention] As explained in full detail above, while making repeatability of plasma treatment good in the microwave plasma equipment of this invention, it can abolish that removal of deformation by the thermal expansion of an adhesion-proof cylinder, crack breakage, or an adhesion-proof cylinder becomes difficult.

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**DESCRIPTION OF DRAWINGS**

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**[Brief Description of the Drawings]**

[Drawing 1] It is the typical sectional view having shown a part for the plasma production chamber portion of the microwave plasma equipment of the 1st example.

[Drawing 2] It is the enlarged drawing of the adhesion-proof cylinder attaching part part A in drawing 1 of the 1st example.

[Drawing 3] It is the mimetic diagram having shown the adhesion-proof cylinder maintenance means 8 of the 1st example.

[Drawing 4] It is a typical sectional view for the adhesion-proof cylinder attaching part which looked at the B-B' cross section in drawing 2 of the 1st example from the arrow head.

[Drawing 5] It is a typical sectional view for an adhesion-proof cylinder attaching part at the time of using the coiled form spring of the 1st example.

[Drawing 6] It is the typical sectional view having shown a part for the plasma production chamber portion of the microwave plasma equipment of the 2nd example.

[Drawing 7] It is the mimetic diagram of the adhesion-proof cylinder of the 2nd example.

[Drawing 8] It is a mimetic diagram explaining how to attach the adhesion-proof cylinder of the 2nd example.

[Drawing 9] It is the typical sectional view of conventional microwave plasma equipment.

[Drawing 10] It is the typical sectional view having shown a part for the plasma production chamber portion of conventional microwave plasma equipment.

[Drawing 11] It is the typical sectional view having shown a part for the plasma production chamber portion of another conventional microwave plasma equipment.

**[Description of Notations]**

2 Microwave Installation Aperture

7 Adhesion-proof Cylinder

7a The top-face section of an adhesion-proof cylinder

7b The cylinder part of an adhesion-proof cylinder

8 Adhesion-proof Cylinder Maintenance Means

8a Adhesion-proof cylinder retaining ring

8b Hole

8c Bolt

8d Flat spring

8e Bolthole

8f Bolt

8g Coiled form spring

8h Support plate

8i Bolthole

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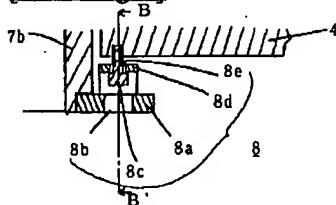
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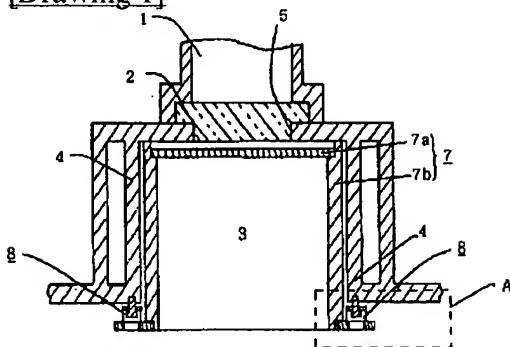
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## DRAWINGS

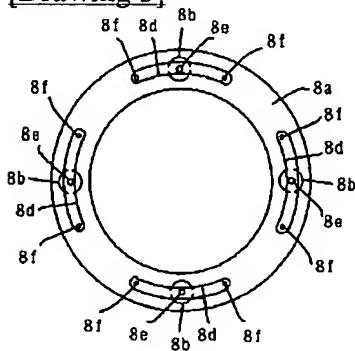
### Drawing 2



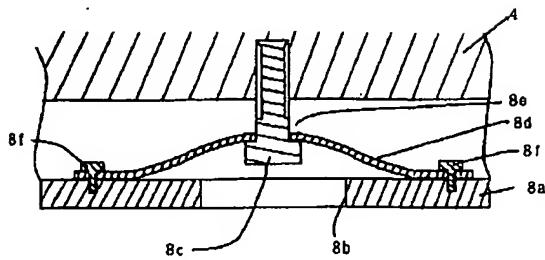
### [Drawing 1]



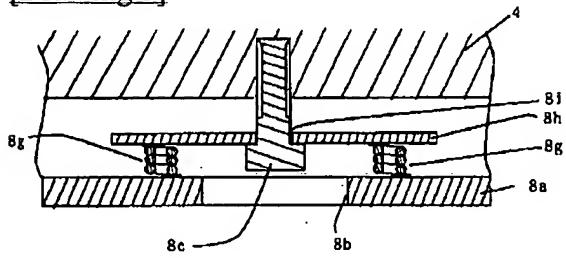
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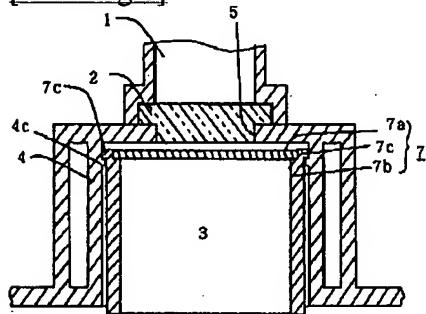
[Drawing 4]



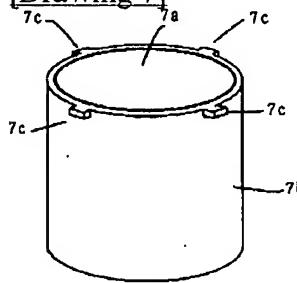
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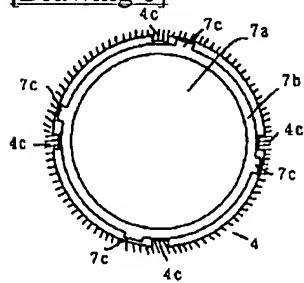
[Drawing 6]



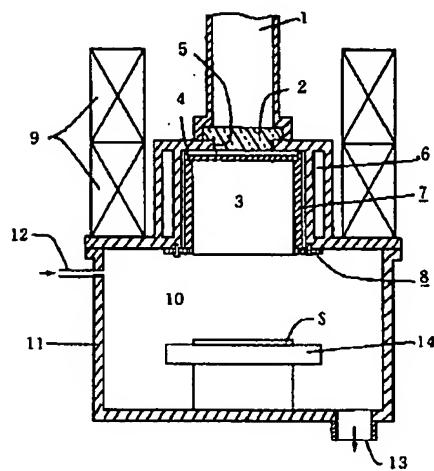
[Drawing 7]



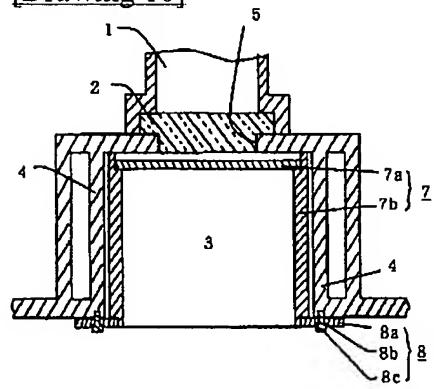
[Drawing 8]



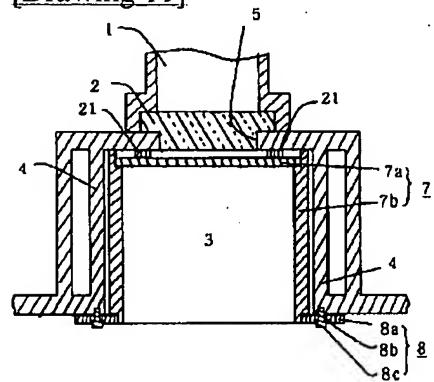
[Drawing 9]



[Drawing 10]



[Drawing 11]



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